

Imaging the Neonatal Brain:

Practical aspects, pathologies and protocols

Mary A Rutherford MD FRCR FRCPCH

Professor in Perinatal Imaging

Robert Steiner MR Unit, Imaging Sciences Department

Clinical Sciences Centre, Imperial College

Hammersmith Hospital, Du Cane Road London W12 OHS

m.rutherford@imperial.ac.uk

Practical issues

MR imaging has a vital role to play in assessing the neonate with encephalopathy. Unfortunately MR imaging of the sick neonate is not easy and experience is limited to relatively few centres, both in the practicalities of performing a successful examination and in the interpretation of the results.

Sedation

Successful imaging of the neonatal brain requires careful preparation of the infant and close cooperation between radiologist, radiographer and neonatologist. Neonates may be successfully imaged during natural sleep, following a feed or under light sedation. We use chloral hydrate at a dose of between 25-50 mg/kg orally, via nasogastric tube or rectally. We keep the infant nil by mouth for at least an hour prior to administration as this will aid absorption of the chloral hydrate which we administer approximately 15 minutes prior to the start of the examination. Neonates will then usually sleep through a 30-45 minute examination. Severely encephalopathic neonates may not require sedation or may already be sedated by anticonvulsant medication. All neonates, sedated or not, should be monitored during scanning with MR compatible pulse oximetry and ECG. A paediatrically qualified member of staff should be in attendance throughout the scan.

Safety

Excessive noise, particularly with fast sequences such as diffusion weighted or perfusion weighted imaging, may wake a sleeping infant or harm the developing auditory system and ear protection should be used. We use mouldable dental putty as individualised earplugs and neonatal earmuffs (Natus minimuffs). Infants may move even when asleep: moulded air bags or foam placed snugly around the infant's head will keep this to a minimum. Swaddling the infants will keep them warm and also reduce movements. Full metal checks need to be carried out with particular attention, in this population, to the presence of intravenous scalp lines, long lines, EEG electrodes, intraventricular shunts and metal fasteners on baby clothes. All non radiological staff involved in neonatal imaging need to be trained in MR safety

Hardware and software adaptations

For optimal image quality the signal to noise ratio needs to be maximised by using a closely fitting coil. In the absence of a dedicated neonatal head coil an adult knee coil may be used. This will normally accommodate an infant up to about six weeks post term. Phased array coils may provide improved benefit in terms of signal to noise even if designed for the adult brain. MR compatible ventilator equipment may be required for the sickest infants but in the absence of this a neonate can be safely hand bagged during a short MR examination. A larger adult type coil may be necessary to accommodate the endotracheal tube in infants requiring ventilation.

Clinical indications for scanning

We would recommend MR imaging on the following clinical situations.

In any neonate with: dysmorphic features, abnormal neurological signs e.g altered tone or consciousness, an abnormal cranial ultrasound, a history of seizures, severe jaundice or symptomatic hyoglycaemia. MR imaging should always be used as an adjunct to cranial ultrasound. It will usually provide more detailed information about lesion site and severity, it may identify further unsuspected abnormalities particularly in areas which are more difficult to assess with ultrasound such as the cortex or posterior fossa. When MR imaging has identified a "new" lesions it is good practice to reperform a cranial ultrasound to see whether it is identifiable in retrospect.

MR imaging can provide important prognostic information in acquired abnormalities such as parenchymal venous infarction, periventricular leucomalacia, perinatal infarction or stroke and in infants with hypoxic-ischaemic encephalopathy.

Imaging Protocols

The majority of neonatal studies have been performed at 1 or 1.5 Tesla but 3 Tesla scanners are now commercially available and may eventually replace many 1.5 Tesla systems particularly for brain imaging. Most MR sequences designed for imaging the adult brain need to be adapted to obtain high quality images of the immature brain with its higher water content. As a minimum we would recommend imaging in at least two planes preferably transverse and sagittal and with at least two sequences T1 and T2 weighted. The exact imaging parameters, depends on the specific system and magnet strength being used. Our parameters for neonatal brain imaging at 1.5 Tesla are shown in table 1.

We would routinely perform the following sequences:

- T1 weighted sequence acquired in the transverse plane. This is ideal for assessing the basal ganglia and thalami and provides the best views of the posterior limb of the internal capsule.
- T2 weighted sequence acquired in the transverse plane. This is better than T1 weighted imaging for identifying early ischaemic change and provides excellent grey/white matter contrast in the very immature brain.
- T1 weighted sequence acquired in the sagittal plane. A volume acquisition is ideal as it provides thin slices and can be reformatted into any plane. It can also be used for absolute quantification of brain structures.
- Diffusion weighted imaging which is ideal for early (< 1 week) identification of ischaemic tissue.

In addition we may add the following:

- A venogram to exclude the presence of sinus thrombosis and differentiate this from subdural haemorrhage.
- Intravenous contrast, gadolinium dimeglumine gadopentetate at a dose of 0.2mls/kg, in suspected infection.

- Angiography to look at both cerebral and neck vessels, which may be abnormal in focal stroke.
- We would not routinely perform a FLAIR examination until at least nine months of age.

TABLE 1

Sequence	TE (ms)	TR (ms)	TI (ms)	Slice thickness (mm)	ns a	Matrix	FOV (mm)	Other
T1 weighted conventional spin echo	15	500	–	4	2	192×256	220–240	
T2 weighted fast spin echo	208	4000	–	4	2	192×256	220–240	
T1 weighted volume acquisition	4.5	30	–	1.6	1	192×256	220–240	
Inversion recovery	30	3500	1000	4–5	2	192×256	220–240	
Diffusion weighted imaging	6000		90	4	1	112×112	240	<i>b</i> value, 750

Timing of neonatal scans.

The timing of a scan may be dictated by availability on the scanner. Ideally however the scan should be timed to ensure the best chance of obtaining information on prognosis. In term born infants presenting with seizures, this would be during the second or third week after delivery. This is a time when lesion conspicuity is at a maximum and information can be obtained with regard to the timing aetiology of the injury and the severity of outcome. In some cases it may be relevant to obtain information during the first few days after delivery. Ischaemic lesions at this stage will be less conspicuous but even conventional imaging is unlikely to be completely normal. To identify early ischaemic injury we would recommend that diffusion weighted imaging is always added to the examination especially in scans performed during the first 10 days from delivery. In infants with suspected malformations the scanning could be performed at any time unless the infant is requiring assisted ventilation and there are concerns about whether continues life support is appropriate. If there is a concern about increasing ventricular size then clearly the examination should be performed promptly so that arrangement can be made to alleviate any raised intraventricular pressure.

In the preterm infant early scanning may be required to obtain an accurate diagnosis but in lesions that have been identified on serial cranial ultrasound it may be appropriate to wait until term equivalent age. At this time information obtained from the appearances of the posterior limb of the internal capsule and from the thalami may be used to predict the severity of motor outcome.

Sometimes an infant may die before he/she can be imaged. MR imaging can provide important diagnostic information for several days post mortem and is to be recommended particularly if consent for a conventional autopsy has been refused or it cannot be undertaken.

References:

MRI of the Neonatal Brain. Rutherford MA (ed) WB Saunders 2002

Recent advances in imaging the fetus and newborn. Semin Fetal Neonatal Med.

Cowan FM and Rutherford MA (eds) 2005